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Teaching a Foreign Language Lexicon: A Rationale for Hypertext

V. Melissa Holland
U.S. Army Research Institute

August 1990

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United States Army Research Institute
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Technical Report 906

Teaching a Foreign Language Lexicon: A Rationale for Hypertext

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**Human Performance Effectiveness
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FOREWORD

Acquiring and retaining a large foreign language lexicon of technical and military terms is a significant problem for Army linguists. Linguists are expected to learn the bulk of the terms not through general language instruction at the Defense Language Institute, but as part of training for their MOS or as part of the job. Yet proficiency tests and survey ratings of both new arrivals and incumbent linguists indicate major deficiencies in knowledge of mission-essential terminology.

Contributing to deficiencies in mission-essential terminology is a shortage of instructors to teach job-specific foreign language in the schools and in the field and demonstrated shortcomings of available paper-and-pencil methods. To help ensure that vocabulary skills are acquired and maintained, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has begun exploratory development of computer-based foreign language learning and retention programs. The aim of this work, sponsored by the U.S. Army Intelligence Center and School, is twofold: to assess the nature of lexical knowledge and the processes of language acquisition through original research and review of existing studies, and to draw on emerging computer technologies like hypertext to apply the research findings. This report reviews the relevant research and shows how it guides the design of ARI's prototype foreign language learning programs. The principles of design described in this report, shaped by advances in cognitive science and psycholinguistics, have potential application to teaching technical vocabulary in a range of foreign languages and for a variety of Army occupations.



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TEACHING A FOREIGN LANGUAGE LEXICON: A RATIONALE FOR HYPERTEXT

EXECUTIVE SUMMARY

Requirement:

Army linguists must acquire and retain a large foreign language lexicon of technical and military terms. Linguists are expected to learn the bulk of these terms not through general language instruction at the Defense Language Institute (DLI) but as part of training for their MOS or as part of the job. Yet proficiency tests and survey ratings of both new arrivals and incumbent linguists indicate major deficiencies in knowledge of mission-essential vocabulary, among other aspects of foreign language competence. Compounding the problem is the shortage of instructors to teach job-specific foreign language in the schools and in the field and the general ineffectiveness of available paper-and-pencil methods. In response to this problem, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has initiated exploratory development of computer-based foreign language learning programs, focusing on the foreign language terms used by Army interrogators, MOS 97E. The aim of this work, sponsored by the U.S. Army Intelligence Center and School (USAICS), is twofold: to assess the nature of lexical knowledge and the processes of language acquisition by tapping original and existing research, and to apply the research findings through emerging computer technologies like hypertext.

Procedure:

This report reviews several lines of research in psycholinguistics and cognitive science concerning the structure of lexical knowledge, its role in language use, and the processes by which it is acquired. These findings are then translated into cognitive requirements for learning a specialized lexicon in a foreign language. Finally, the report describes a series of foreign vocabulary learning programs now under development at ARI. A rationale for each program is given in terms of how it meets the cognitive requirements identified in the research review.

Findings:

The research reviewed in this report points to lexical knowledge as highly structured and interconnected, as represented by semantic networks. The implication for vocabulary instruction is that the same network organization can be used to present new

words. To support such presentations, the logical software tool is hypertext. Hypertext enables words to be displayed with multiple links between them as well as with links to sounds and images. Thus, hypertext was the development tool of choice for the foreign language learning programs described here. In addition, the research reviewed yields specific principles for structuring vocabulary presentations, and these principles are reflected in the learning programs described here.

Utilization of Findings:

The principles of design described in this report, shaped by advances in cognitive science and psycholinguistics, have potential application to teaching technical vocabulary in a range of foreign languages and for a variety of Army occupations. The particular programs described in this report are being translated into foreign languages beyond those represented here and will be evaluated with students at USAICS (Fort Huachuca) and at DLI.

TEACHING A FOREIGN LANGUAGE LEXICON: A RATIONALE FOR HYPERTEXT

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Teaching a Foreign Language Lexicon: A Rationale for Hypertext

Overview

To carry out their jobs, military linguists need specialized knowledge of a foreign language. However, the language training they receive at the Defense Language Institute (DLI) is limited to general conversational and reading skills. To help military linguists acquire foreign language knowledge specific to their jobs, the Army Research Institute (ARI) is assessing the use of hypertext for computer-assisted language learning (Psotka, Holland, Swartz, and Hanfling, 1988; Swartz and Psotka, 1989) and has designed a series of experimental hypertext programs. These programs focus on one critical aspect of job-specific language - the lexicon of foreign technical and military vocabulary needed in the field. Jobs like tactical interrogation, document translation, communications analysis, and intelligence interpretation require, among other language skills, understanding and using well-defined occupational jargons in the target language. (Note 1)

Our vocabulary learning programs, now in different stages of development, are described in separate reports (Bui, in preparation; Hamburger, 1989; Oxford, in preparation; Psotka, Holland, Swartz, and Hanfling, 1988; Swartz, in press; Swartz and Psotka, 1989). This paper attempts to link these programs by defining a common rationale for their network approach to presenting vocabulary and for the features of hypertext used in the presentation. Recent applications of hypertext have been criticized for failing to consider the cognitive justification and appropriateness of this new technology (Charney, 1989; Hanfling, in preparation; Jonassen, 1989; Kostyla and Hanfling, 1990; Spiro, 1990). It is in view of this criticism that we explicate a rationale for hypertext in the specific case of lexical instruction.

We present this rationale in two parts. First, we review both practical and theoretical aspects of the training problem. This review lays out the cognitive requirements of learning and retaining vocabulary in a foreign language. We then describe our approach to developing solutions, which seeks to meet cognitive requirements by drawing on tested principles for organizing and retaining word knowledge. After presenting the rationale, we illustrate how these principles are reflected in three prototype vocabulary learning programs.

The Problem

From a practical standpoint, acquiring and maintaining specialized vocabulary in a foreign language is difficult for military linguists. Their primary language training, at DLI, fosters general language skills and teaches a vernacular vocabulary. Vocabulary specific to an occupation is intended to be introduced during subsequent job training or to be acquired on the job.

The language learning problem faced by military linguists is typified by Army interrogators, MOS 97E, the population of initial concern in our work on computer-assisted language learning. Trained at the U.S. Army Intelligence Center and School (USAICS), interrogators must master a dedicated vocabulary in their target language to probe tactically relevant topics like troop strength and location, types of available weapons, map and compass indices, and battlefield strategy. At the same time, to accommodate the diversity of second languages spoken by students, interrogation classes are conducted entirely in English. The requisite foreign vocabulary must be learned outside of class in language lab. Typically, students get lists of hundreds of technical and military terms in their respective languages and then memorize the terms, usually by pairing them with the corresponding English words.

This rote method is demonstrably ineffective for learning new words. Tests given at the end of training, in which students translate interrogation scripts into their respective target languages, show consistently low scores, which instructors attribute in part to gaps in students' knowledge of job-relevant vocabulary. (Note 2)

Finding a practical alternative to rote word learning is difficult. First, interrogation instructors do not speak the range of languages necessary to help all students practice using the terms they are studying. Resources are insufficient to retain instructors proficient in each language that might be represented by students. Second, there are no paper or computer aids available to these students that capitalize on what is known about the acquisition and structure of lexical knowledge.

Complicating the problem, interrogators encounter few experiences on the job to compensate for inadequate language preparation. Indications from the field are that exposure to the target language is sporadic both on and off the job; thus, soldiers not only fail to acquire new vocabulary but may also forget vocabulary they have already learned (ManTech, 1986). Even if foreign language skill is not immediately needed on the job (indeed, few interrogations are conducted in peacetime), it is critical to maintaining readiness.

The problem of teaching and sustaining job-critical terminology is a major impetus for our current work. We expect the solutions we are developing to apply beyond the problem of the military linguist to the problem of acquiring any focused lexicon in a foreign language.

Approach to Solving the Problem

Our approach to developing vocabulary instruction is twofold. We seek first to draw on research from cognitive science to justify the design of instruction, and second to exploit advanced computer technologies to implement cognitively justified designs.

Observing the Structure of Lexical Memory: The View from Cognitive Research

To make use of relevant research, our first step is to ask how words are organized in human memory. A body of studies in cognitive science and psycholinguistics has explored people's memory for words - sometimes called lexical knowledge or the mental lexicon. These studies reveal that memory for words is highly structured along systematic logico-semantic dimensions. That is, some words appear closer together, or more strongly linked in memory, than others (Collins and Quillian, 1969; Deese, 1965), and many of the links come from a small set of well-defined semantic types (Miller, Fellbaum, Kegl, and Miller, 1988; Miller and Johnson-Laird, 1976).

A prominent type of semantic link is class inclusion:

"An M-16 is a rifle, a rifle is a weapon."

This type of link creates a hierarchy of "is-a" relations, as shown in Figure 1. The "is-a" hierarchy is a primary organizing principle for knowledge of nouns. It also applies in modified form to verbs, as pointed out by Fellbaum and Kegl (1988) and Collier and Fellbaum (1988) - for example, "sailing is a kind of boating, boating is a kind of traveling." In logic, the class-inclusion relationship is termed hyponymy.

Another prominent type of link is part-whole:

"A rifle has a stock, a stock has a butt."

This link, unique to nouns, also creates hierarchies in the mental lexicon, as illustrated in Figure 2. In logic, the part-whole relationship is termed meronymy.

Other salient links that characterize our knowledge of words include synonymy ("weapons"- "arms"), which applies to all parts of speech, and antonymy ("high"- "low"), which applies pervasively to adjectives and adverbs and selectively to verbs and nouns ("advance"- "retreat," "giant"- "dwarf"). Semantic links with more limited application include attribution ("yellow"- "canary") and locative inclusion ("September"- "Fall"). Speakers also recognize pragmatic relationships between words ("baby"- "bottle," "knife"- "steak") based on how the corresponding objects are typically situated in the world (Columbo and Williams, 1990; Sanford and Garrod, 1981).

Clearly, any word will have a variety of links to other words in memory. Thus, lexical memory can be thought of as a network with multiple pre-existing interconnections, some of which form hierarchies. A possible network structure for a sample of lexical memory is shown in Figure 3. The points of connection, or nodes, of the network are words and the links represent semantic relationships that can be specified and labeled. Note that this network contains a mixture of relationships (e.g., class-inclusion, part-whole, and

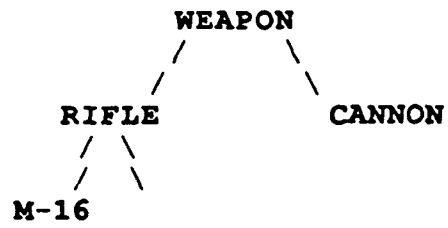


Figure 1. Portion of a class-inclusion ("is-a") hierarchy for "weapon."

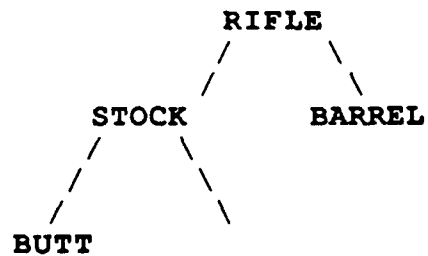


Figure 2. Portion of a part-whole ("has-a") hierarchy for "rifle."

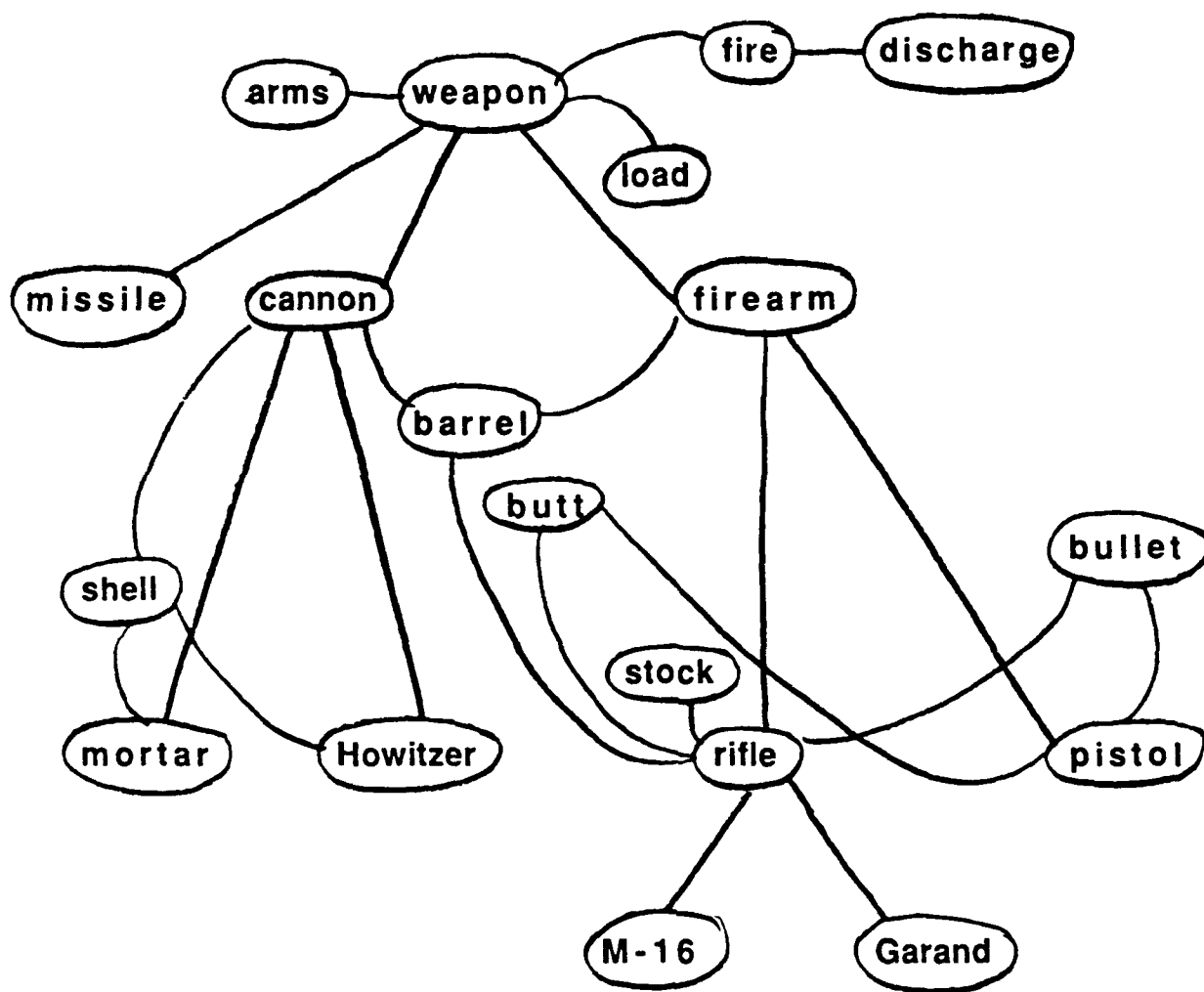


Figure 3. A hypothesized network structure for a sample of lexical memory.

attribution), while the hierarchies in Figures 1 and 2 isolate a single relationship.

The idea of representing lexical memory as a semantic network with labeled links that are more or less standard across speakers is widely accepted in cognitive science (Anderson, 1983; Collins and Quillian, 1969; Forster, 1976; Kintsch and Mross, 1985; Meyer and Schvaneveldt, 1971; Miller et al., 1988; Miller and Johnson-Laird, 1976). Preceding the models of lexical memory developed in cognitive science, research in verbal learning viewed the links between words in terms of learned associations (Deese, 1965). Studies of word associations have shown that, in addition to systematic semantic links, individual speakers may encode idiosyncratic associations between words based on personal experience ("September"- "anniversary"). But these associations are considered to be non-linguistic, to lie outside the common store of word knowledge (Miller and Johnson-Laird, 1976). The common set of associations emerges statistically from studies of how a range of people associate words. (Note 3)

It is the links in this common store that have demonstrated powerful and uniform effects in studies of human memory. We will briefly review these effects to provide evidence for links between words in memory and to illustrate the consequences of a tightly and intricately interwoven lexicon for language processing.

The role of lexical links in word recall, word association, and word sorting tasks. Early demonstrations of common and systematic links between words in memory came from the verbal learning literature and included studies of free recall of word lists (Bower, Clark, Lesgold, and Winzenz, 1969; Bousefield and Cohen, 1965; Mandler, 1967; Tulving, 1962) and tests of word association (Deese, 1965; Palermo and Jenkins, 1964). In tests of word association, people are asked to respond to a stimulus word: "Tell me the first word that comes to mind when I say ____." The response words tend to be consistent across people and to reflect principled semantic relationships to the stimulus word. For example, "dog" frequently elicits "animal" as a response (the hyponymy relationship) and "wet" frequently elicits "dry" (the antonymy relationship).

In studies of free recall of words, people are asked to study a list of words and later to write them down in any order from memory. Words that are conceptually related in the list tend to be recalled together, yielding response protocols with semantic clustering. For example, words referring to one topic, like animals, might be recalled adjacently and separately from words referring to another topic, like plants; and under animals, words referring to birds might be recalled separately from words referring to insects. These clusters emerge regardless of how the words were sequenced in the lists that people studied - for example, plant and animal words might originally have been interspersed. Not only do these clusters reflect principled semantic dimensions - for example, hyponymy ("a bird is an animal") -

Clustering in free recall can be inferred to arise because certain words have prior links in memory and serve as retrieval cues for one another. For example, retrieving "bird" cues the retrieval of "robin" because those words have a direct line to each other. In addition, because words are linked in conceptually related categories, a category label like "bird" can cue retrieval of a whole set of words. Thus, people can use preexisting hierarchical links to organize their recall of a list of words. They can chunk items scattered in the list under one label. Then, by recalling the label, they can more readily retrieve the subordinate items. Lists with obvious semantic connections that invite chunking are measurably easier to recall than lists with randomly selected items (Bower, Clark, Lesgold, and Winzenz, 1969; Bousefield and Cohen, 1965).

Another paradigm that demonstrates systematic links between words in memory involves people's judgments of semantic relatedness. People can judge the relatedness of words by rating them or by sorting them together into groups. In the word sorting method, people receive a set of several words, each written on a card, and are asked to group together the words they think are similar in meaning. The percentage of people sorting a pair of words together is a measure of the perceived semantic closeness of those words. A statistic is applied to measure the average perceived closeness between words for all possible pairs in the sample. The results show words linking together in clusters that are tighter and cleaner the more people have agreed in their sorting. The clustering obtained through this method has been used in investigations of lexical structure to uncover specific links between words as well as general lines along which word knowledge is organized (Miller, 1969; Miller and Johnson-Laird, 1976).

In a recent study conducted at USAICS, we used the word sorting method to explore 97E students' knowledge of a sample of military-related vocabulary. Students received a set of 61 English words, each on a separate card, and worked individually to sort the words into groups according to meaning, using whatever criteria made sense to them. We stressed that there was no right way to group the words.

We recorded the groups created by each student in the study and submitted the combined data to an analysis of clustering. Several tight clusters emerged, indicating that students were consistent in their judgments of semantic closeness. These clusters were especially cohesive among technical terms and suggested a prevailing tendency to form "is-a" groupings, such as putting words for types of weapons into one group and words for types of occupations into another. The boundaries of the "is-a" groupings, moreover, appeared relatively stable across students. These observations show that students will recognize and use the "is-a" criterion to sort words drawn from inclusion classes, suggesting a common knowledge structure among 97Es with regard to such words. These data, to be published in a formal report (Holland and Kostyla, forthcoming), can serve as a basis for deciding how to group military terms for vocabulary instruction in a foreign language: We can hypothesize that instructional groupings that match the pre-existing knowledge structure of 97Es will facilitate word learning and retention.

The role of lexical links in natural language uses. Beyond their importance for learning and sorting sets of isolated words, lexical links appear critical for natural uses of language, such as listening and reading. Listening and reading require accessing the meanings of presented words, processes that can be approximated in tachistoscopic studies of word recognition (Collins and Quillian, 1969; Columbo and Williams, 1990; Forster, 1976; Fischler and Bloom, 1979; Kintsch and Mross, 1985; Meyer and Schvaneveldt, 1971; Meyer, Schvaneveldt, and Ruddy, 1972; Swinney, 1979; West and Stanovich, 1988). A typical paradigm is to flash a word or nonword stimulus ("gun" vs. "gur"), either in isolation or in a sentence, onto the screen of a viewing booth. People are asked to make decisions as quickly as possible about whether that stimulus is or is not a word.

Records of decision times from these studies show that word-nonword decisions go faster when people are shown a semantically related word ("rifle") immediately before the stimulus ("gun"). This result suggests that presented words tend to prime or activate related words, making them easier to find in memory. Thus, "rifle" primes memory for "weapon," "gun," and other associates and leads them to be more quickly identified in the word-nonword decision task. The theoretical explanation holds that semantically related words are connected in memory, that these connections form a semantic network, and that the entire network becomes primed in a kind of chain reaction, or "spreading activation" (Anderson, 1983; Collins and Loftus, 1975). That is, if one item in the network is activated, this activation spreads over the connections to other related words. These words then become readily accessible for subsequent recall or recognition.

In general, the effect of anticipatory priming is to make subsequent recognition of the primed words measurably faster than when they are presented in isolation (not preceded by a related word). The facilitating effect of priming on recognition and response time is seen in other psycholinguistic tasks, such as verifying whether sentences are true or plausible (Rips, Shoben, and Smith, 1973).

Tachistoscopic presentation permits the pace of word and sentence display to be carefully controlled and individuals' response time to be precisely measured. Although tachistoscopic studies only simulate the conditions of realistic language use, the effect of priming is arguably the same in reading or listening under real-world conditions. Discourse analyses of authentic text and talk reveal that semantically related words co-occur densely (eg, "cohesion by collocation," Halliday and Hasan, 1975), creating a natural role for semantic priming. Thus, if semantic associates of an initially encountered word like "rifle" are activated automatically, they should be easier to recognize and retrieve when they appear in immediately following portions of a text or discourse. Associated words can be seen to form a semantic field or domain (Nida, 1975) - a set of interrelated concepts on the same topic, like colors or animals. These domains enter often into conversation and reading. Thus, if all the words in a semantic domain are activated when one of the domain is accessed, this should facilitate word recognition and retrieval during conversation about the domain. Of course, not all the words activated

by priming will appear in a given episode of text or talk, but many of them will if the episode is coherent. As Kintsch (1988) demonstrates, the priming of word senses occurs blindly and rapidly, before the contexts of sentence and discourse select particular word senses and inhibit spreading activation.

How does priming facilitate word recognition in real language episodes? A pre-activated network of associates serves to constrain the reader/hearer's expectations about what comes next in a sentence or utterance. If reading and listening are seen as processes of hypothesis-testing (Adams and Collins, 1979), then the ability to predict or limit the possibilities for upcoming words makes those processes easier. In fact, increased predictability has been found vastly to improve the comprehensibility of text and the intelligibility of speech in studies of speech shadowing, cloze passage completion, and sentence recognition under noisy conditions (Marks and Miller, 1964; Miller, 1962; Miller, Heise, and Lichten, 1951; Miller and Isard, 1963). It seems that semantic expectations not only simplify but are necessary for on-line processing of text and speech.

The connection between semantic expectations and spreading activation through lexical networks is seen experimentally in the "sentence superiority effect": A word is recognized faster when seen in a sentence than it is in isolation (Alington, 1978; Berninger, 1989; Perfetti, Goldman, and Hogaboam, 1979; Stanovich 1982; West and Stanovich, 1978, 1988). The effect of context is especially strong if the sentence contains close associates of the word to be recognized - "He kept his gym clothes in the ___[locker]." But it may occur in plausible sentences even when the association is not so close - "He kept his gym clothes in the ___[closet]" (Columbo and Williams, 1990; Stanovich and West, 1983; Swanefflugel and LaCount, 1988). It is theorized that plausible sentences constrain possibilities through spreading activation that facilitates words in a semantic network. The scope of facilitation ranges over large portions of the semantic network, which remain activated over time (Schwanefflugel and LaCount, 1988).

Beyond listening and reading, lexical links appear equally critical for speaking and writing. Speaking and writing require retrieving words to express needed meanings and are more akin to recall than to recognition tasks. Spreading activation over lexical links should help recall by increasing the availability of words within a domain. Moreover, memory research indicates that items which are more elaborated, or more richly interconnected to other items in memory, are easier to retrieve (Craik and Lockhart, 1975). Their greater "depth of encoding," as the interconnectness is termed, makes it more likely that the words will be recalled in production tasks like writing or speaking.

Drawing Instructional Implications: Using Lexical Links in Vocabulary Instruction

The experimental evidence we have reviewed points to the importance for native speakers of a structured lexicon with dense intercon-

nections that guide expectations and anchor retention. The evidence also reveals how the lexicon is structured in some domains. We inferred from this review that acquiring lexical structure is a rational and necessary goal for foreign language learners. Not only must learners grasp the meaning of a new word in terms of its translation, definition, external referent, and rules of use, but they must also integrate the word with other new words and with the existing lexicon. To be effective, this integration should follow the conventional semantic organization of the native speaker. Moreover, it should be robust enough that inter-word associations occur rapidly and relatively automatically. Otherwise, learners of the language would never understand naturally paced speech or read at efficient rates.

We inferred that learners can acquire lexical structure through vocabulary instruction that explicitly presents lexical links, introducing words in the same organized form that they appear to exist in memory. For example, presenting words from a semantic domain together should strengthen the links between the words and increase the likelihood that they will activate each other when one of them is accessed. (Note 4)

We further inferred that vocabulary instruction should foster automatic connections by presenting groups of foreign words without mediation by English or native language words, a kind of simulated immersion method (Hamburger, 1989). Immersion approaches, such as represented by communicative language teaching (Johnson and Porter, 1983), are favored by language teachers and supported by evidence (Asher, 1966; Brown and Yule, 1983; Krashen, 1982). Broad evaluations of language teaching methods (e.g., Fuentes, 1979) suggest that reliance on native language mediators, as when learners study lists of native and foreign word pairs and encode the pairings, are of questionable effectiveness, even when enhanced by mnemonics like the key word technique (Atkinson, 1975). Indeed, mediation methods may promote translation strategies and impede the development of foreign language fluency (Cohen, 1987; Cohen & Aphek, 1980). The next step in our approach, then, was to find tools for presenting lexical structure in a second language without using the first language.

Selecting Tools to Teach Lexical Links: An Assessment of Hypertext

We sought to identify software tools appropriate for presenting the network structure of lexical knowledge. Given the multi-modal nature of word representations (encompassing written, auditory, and imaginal forms), and the multi-dimensional nature of connections between words, we saw hypertext as a logical instructional medium. Hypertext capabilities are found in tools like Macintosh's HyperCard and Xerox's NoteCards.

Hypertext is a logical choice because it offers an efficient way to represent network structures. It lets the designer create collections of facts and then cross reference them, much like putting information on note cards. The cards may be linked in many ways and at many levels to form a web of facts through which an enormous variety of

routes is possible. In fact, this web comes to resemble the lexical memory network illustrated in Figure 3.

The information structure created through hypertext can form an environment for exploratory learning, in which students access the network of facts directly and trace paths open-endedly, moving in any direction. Alternatively, this structure can be used as the underpinning for a development environment, the basis on which designers create more directed instruction. In addition to cross referencing nodes of information, hypertext is uniquely suited to integrating information in several media, such as text, sound, graphical images, and video. This capability, known as hypermedia, makes it easy to link a variety of information sources to a central program, which acts as a switchboard to control their interaction (Hanfling, in press; Psotka, Holland, Swartz, and Hanfling, 1988).

In these respects, hypertext fits the cognitive requirements of word learning and retention: Multi-modal, word-sound-picture representations such as enabled by hypertext resemble the building blocks of word knowledge (Townsend, in preparation) and of effective vocabulary instruction (Oxford, in preparation). In addition, the capability of hypertext to tie these representations together in network patterns allows a hypertext database to mirror the structure of lexical knowledge.

Selecting What Lexical Links to Teach: Looking to WordNet

In considering what aspects of lexical structure to teach, we have drawn from a continuing effort by Miller et al. (1988) to build a computerized lexical network in English, known as "WordNet." This network is an on-line reference system intended ideally to capture psychologically real lexical relations among all words in the language. The system focuses on four primary conceptual relations: synonymy, antonymy, meronymy (class inclusion), and metonymy (part-whole). The latter two relations, which produce hierarchies, were illustrated in Figures 1 and 2. (WordNet may also portray secondary relations depending on the part of speech).

These four relations figure saliently both in psycholinguistic studies of word memory and use and in linguistic studies of the cohesive structure of discourse. For example, in our own linguistic analyses, we find that class-inclusion shifts pervade question-answer routines in samples of everyday conversation and in excerpts of formal interrogations:

"What kind of **weapons** does your unit carry?
"Rifles and automatic pistols."
"What kind of **rifles**?"
"M-16s."

Clearly, the native speaker's ability easily to traverse class-inclusion hierarchies like that involving "weapon" lends to fluent production and rapid comprehension in communicative exchanges.

We also find that synonym and antonym shifts are common in discourse. As Charles and Miller (1988) point out, direct antonym oppositions, like "strong-weak" and "high-low," often co-occur in close proximity in natural discourse, for example:

"After the **high** point of last summer, airline prices reached a **low** point in the fall."

"The spirit is **strong** but the flesh is **weak**."

This co-occurrence, infer Charles and Miller from a large corpus of language samples, is probably responsible for the close link between direct antonyms in memory. In turn, having strong direct links between antonyms helps speakers handle sentences like those above naturally and without hesitation. Charles and Miller found that when such sentences are used in cloze tests, which replace one antonym member with a blank (eg, a blank for the word "high" above), respondents are most likely to fill the blank with the other member of the direct antonym pair (eg, to put "high" rather than "elevated," "zenith," or other words).

The same point can be made for synonymy. Synonym substitution happens often in narratives, essays, and more creative genres that strive for "elegant variation," as in the "crowds-throngs" shift below:

"**Crowds** of people gathered around the square. The **throngs** swelled the streets."

Again, direct links between synonyms are essential for quick understanding and production of such sentences.

A semantic domain could include many relations between words. The above four relations - synonymy, antonymy, part-whole, and class inclusion - are plausible ones to select from the multiple relations in a domain, following the example of Miller et al. (1988) in WordNet.

We hypothesized that if the relations represented in WordNet were used to construct networks in other languages, learners could browse the networks or do exercises based on them, and thereby acquire, practice, and strengthen important lexical links. As in an immersion technique, word configurations would appear solely in the target language, permitting instruction largely to bypass the native language.

A similar method of foreign vocabulary instruction was advocated by Cornu (1979) on a smaller scale. Selecting a limited set of words, she isolated some of the lexical relations now being analyzed by Miller et al. (1988) and graphically configured them on paper for foreign language students. Cornu found several advantages to these structured conceptual maps. Not only do they convey links corresponding to those in the native lexicon, but they show the meaning of individual words iconically, by their placement vis-a-vis known words, without intervention by definitions or translations. For

and the learner already knows the words labeling the endpoints of the scale, then the meanings of words at the midpoints ("warm" "cool," etc.) should be inferrable at a glance. Numerous dimensions on which words can be graphically depicted and meanings made transparent are identified by Bui (in press) and by Hamburger (1989).

Implementing the Approach: Three Prototype Programs

We next sought to implement these design ideas: to create immersion-style hypertext learning environments that display the ties between words. Below are described three hypertext programs being developed at ARI, each building on the WordNet concept. The focus is on aspects of the programs that illustrate the influence of cognitive principles on instructional design and that demonstrate the potential of hypertext to incorporate these principles.

Word Trees

The first program is based on the simple idea of displaying lexical networks in the form of "is-a" hierarchies. Focusing on the military lexicon used in interrogation, we first took the list of several hundred specialized terms given to 97Es and grouped them into obvious semantic domains, like terrain features, weapons and equipment, and officer ranks. We analyzed some of these domains into "is-a" hierarchies, based on our dictionary-informed intuitions about how the words logically relate on the class-inclusion dimension. Helping to confirm our intuitions are the word sorting results from USAICS (Holland and Kostyla, forthcoming): Students' conceptual representations, as indicated by their word groupings, appear to match our logical hierarchies.

The domains that lent themselves gracefully and reliably to class-inclusion hierarchies we are translating into selected foreign languages. The translated hierarchies are then implemented using Xerox's NoteCards system. More about NoteCards appears in Psotka, Holland, Swartz, and Hanfling (1988). A fuller account of our foreign language implementation appears in Swartz and Psotka (1989).

The foreign language implementation displays items in a tree-like network of subordinate and superordinate links. Figure 4 shows a tree of French words for weapons (from Swartz and Psotka, 1989). The screen in Figure 4 illustrates a defining feature of hypertext: Each word in the tree represents a "hotspot" that the user can choose to touch or button on with a mouse (a hand-controlled pointer) to open up further information about the word.

This supplemental information appears on a card that pops up as a boxed inset on the screen. The pop-up card provides such information as a set of synonyms in the target language, a sentence illustrating usage, an English translation, and grammar points. Thus, the "is-a" tree is not intended to carry the entire burden of vocabulary instruction; students can, depending on their needs and wants, see synonyms, contexts of use, syntactic rules, and other word facts.

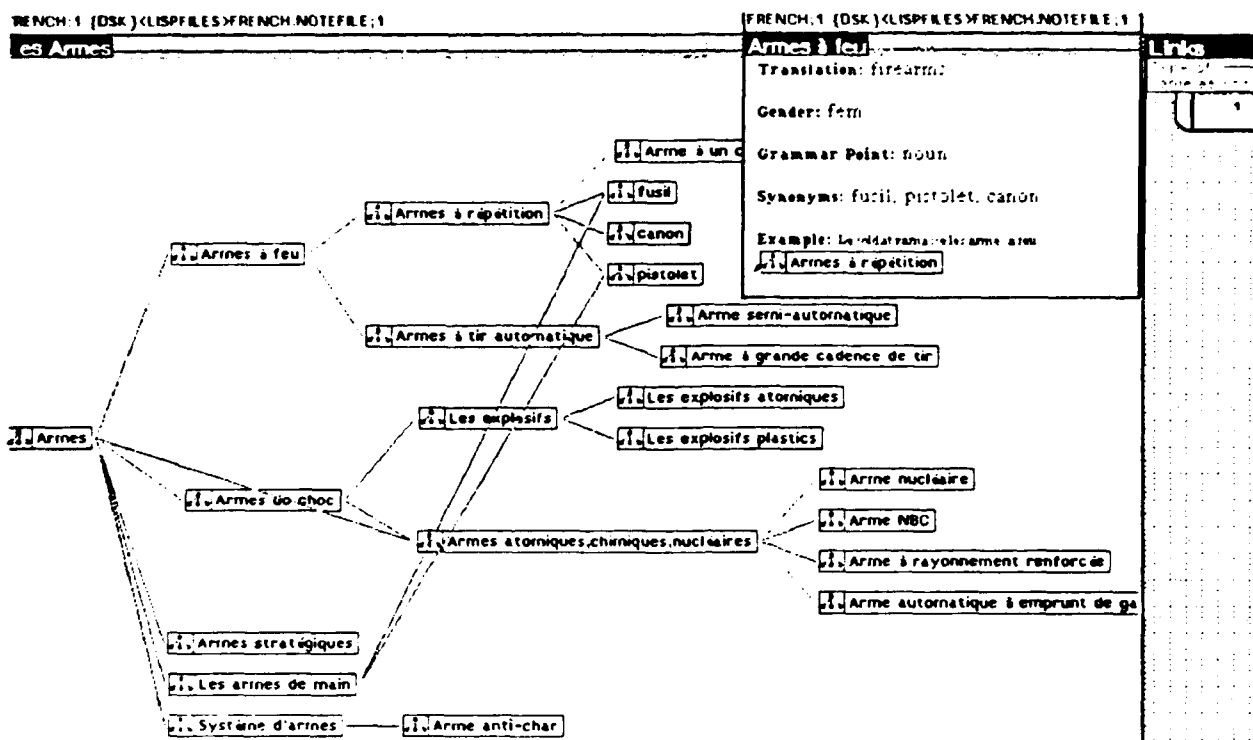


Figure 4. A hypertext screen showing a class-inclusion hierarchy of French terms for weapons.

The NoteCards word tree program is intended as a browser for exploratory learning. The finished program will be tried with students at USAICS to see how well a flexible, learner-controlled environment works for advanced language learners.

The next two programs couple learning by exploration with more directed, interactive instruction built on a hypertext foundation.

HyperLexicon

A demonstration program called HyperLexicon was designed to show the power of Macintosh's HyperCard for vocabulary instruction. This program depicts the meanings of common English words through spatial displays of semantic relationships and through still and animated pictures. A full account of the program is provided by Bui (in press), and a summary appears in Psotka, Holland, Swartz, and Hanfling (1988).

In one component of HyperLexicon, the meaning of words is given by their place in a hierarchy of "is-a" or "part-whole" relations. In addition, each hierarchy is linked to three analogous hierarchies, displayed in quadrants on the screen, as shown in Figure 5. The hierarchy in the upper left of the screen in Figure 5 shows words like "foot" and "head" in part-whole relation to "man." The other three hierarchies show words for the corresponding parts of selected animals in corresponding hierarchical positions. The learner explores analogous relations by working across the hierarchies, choosing sets of parallel words - like "foot," "hoof," and "paw." The accuracy of the choices is signaled by graphical highlights of correct answers.

The meanings of words in the hierarchies is also depicted by pictures of their referents. Pictures are easy to create in HyperCard and can be linked directly to the written words. For example, by buttoning on the word "foot" in the "man" hierarchy, the learner sees a picture of a human foot, as shown in Figure 6. The picture appears in a set of three others representing analogous concepts in the animal hierarchies. Similarly, by choosing the word "man," at the top of the hierarchy, the learner sees pictures of the whole person and animals, as shown in Figure 7. The nesting of pictures at different levels of closeup mirrors the conceptual nesting of words in the part-whole hierarchies.

Another component of HyperLexicon integrates noun and verb hierarchies in order to teach and exercise knowledge of selectional restrictions (the semantico-syntactic rules for pairing subjects with predicates in sentences). For "living thing" nouns and "ingest" verbs, shown in Figure 8, the learner works between the hierarchies, selecting subject-verb pairings. Feedback on the appropriateness of the pairings is provided - for example, "horses graze" and "birds peck," but not vice versa.

As a final device for conveying word meaning, verbs of motion are displayed in geometric arrangement with spatial distance representing semantic distance. Thus, as shown in Figure 9, "walk" and "run" are closer together than "walk" and "fly." By graphing semantic relations

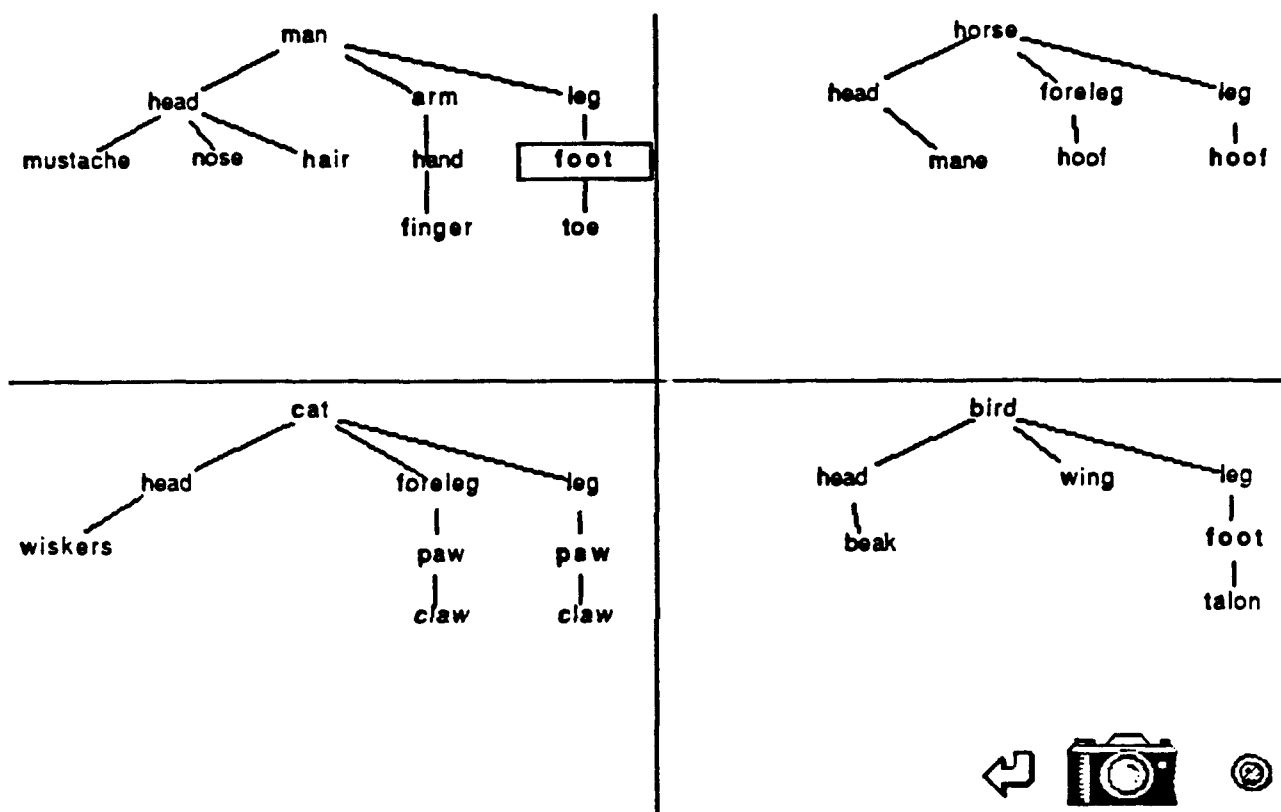


Figure 5. A hypertext display of a part-whole hierarchy for "man" with analogous hierarchies for "horse," "cat," and "bird," from HyperLexicon.

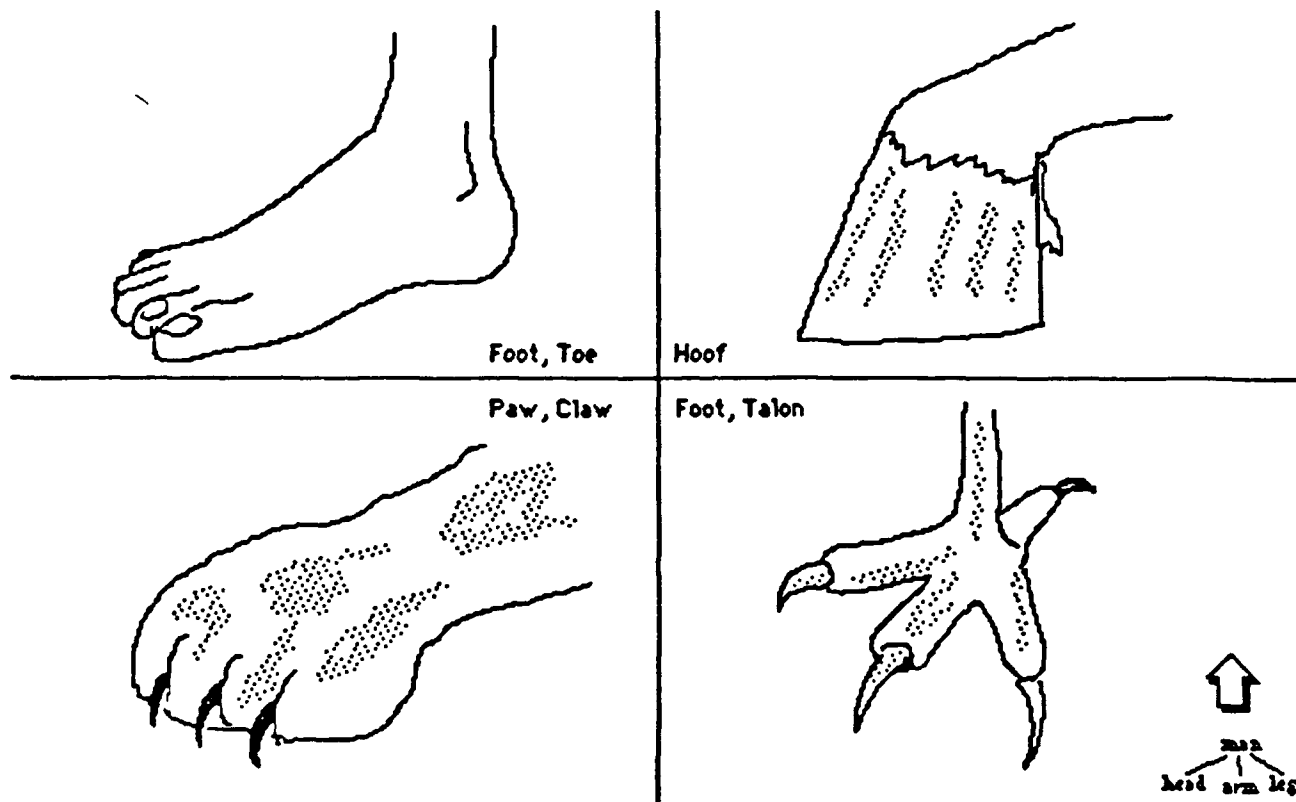
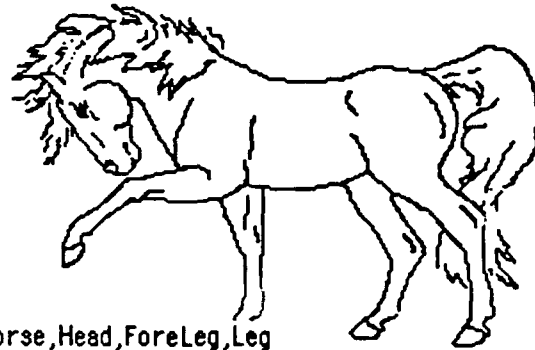


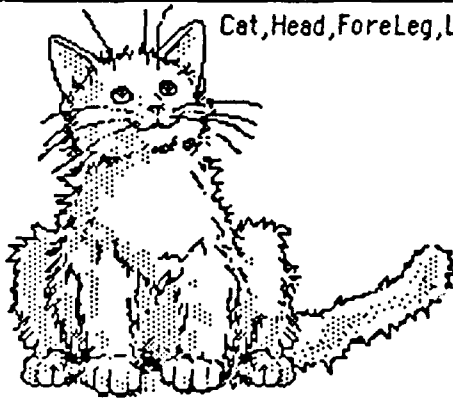
Figure 6. Pictures in hypertext corresponding to "foot" nodes of part-whole hierarchies from Figure 5.



Man, Head, Arm, Leg



Horse, Head, ForeLeg, Leg



Cat, Head, ForeLeg, Leg



Bird, Head, Wing, Leg

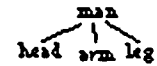


Figure 7. Pictures in hypertext corresponding to top-level nodes in part-whole hierarchies from Figure 5.

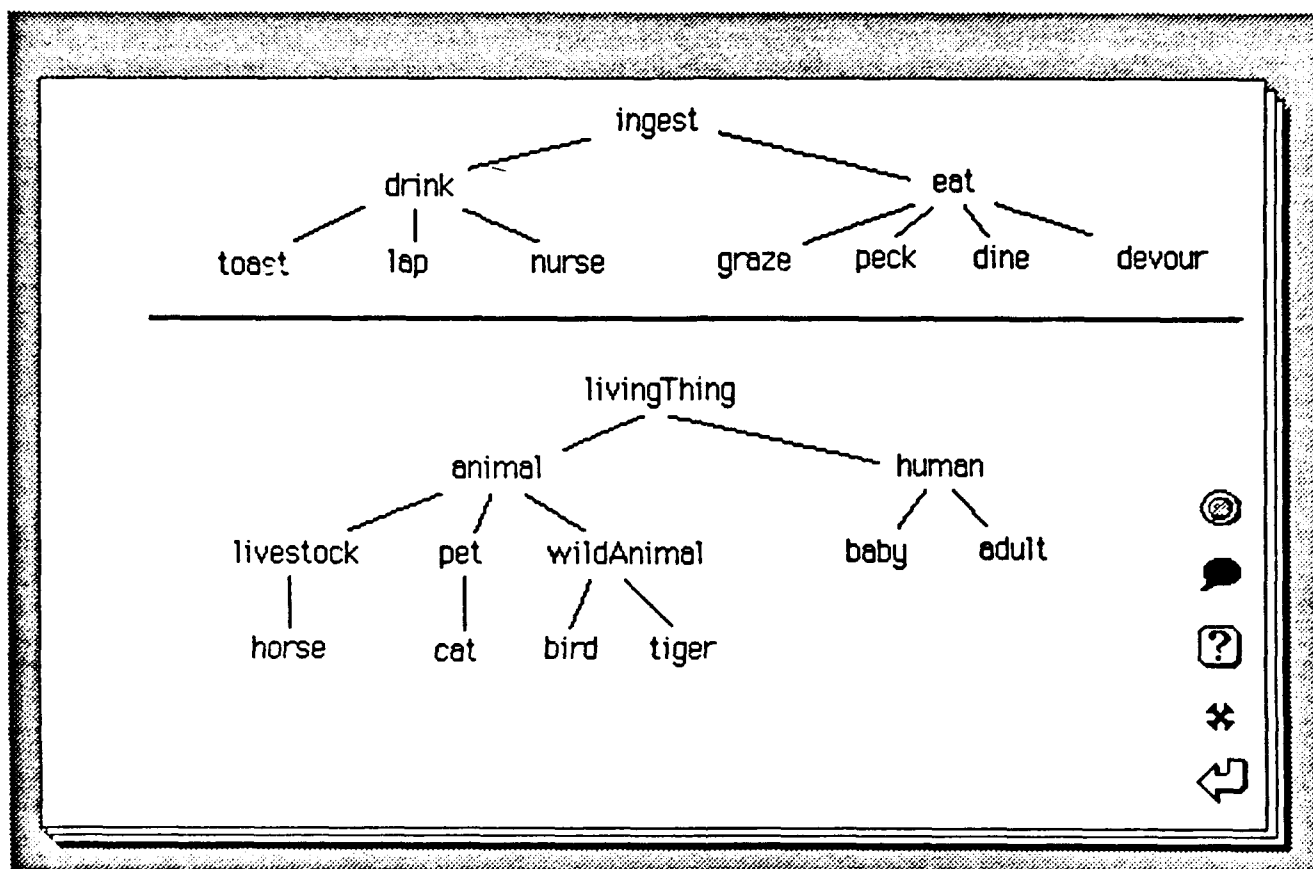


Figure 8. A noun and a verb hierarchy used for pairing subjects and predicates, from HyperLexicon.

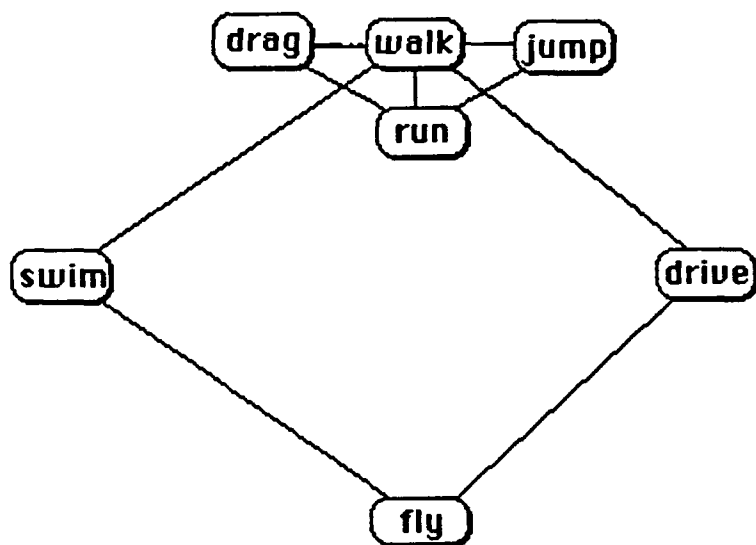


Figure 9. A spatial representation of the semantic distances between verbs of motion. ("Drag" here is used in the intransitive sense of "walking very slowly.")

in this way, the program makes meaning transparent and avoids the necessity of lengthy and intrusive verbal accounts of meaning.

While the demonstration is in English, the principles that underlie this program can easily support foreign language translation. This work paved the way for a more developed program that couples the lexical structure principles of HyperLexicon and with discourse principles.

LEXNET-in-Situ

Also based in HyperCard, LEXNET-in-Situ teaches 33 French words used in military intelligence and provides semantic information on over 100 words. This program extends the first two by situating the lexical networks - integrating them with realistic sentence and paragraph contexts. LEXNET-in-Situ is fully described in Swartz (in press), with a rationale and evaluation methodology presented in Swartz, Kostyla, Hanfling, and Holland (1989).

In this program, potentially unfamiliar words are first encountered in a series of paragraphs that resembles an intelligence report. Figure 10 shows a paragraph from a series on the Iran-Iraq War. Potentially unfamiliar words are highlighted. By buttoning on a word, the learner gets a pop-up menu in French, as shown in Figure 11, with options such as hearing the word pronounced, getting an English translation, seeing a sentence containing the word, and seeing a graph ("reseau") of where the word fits in a network of related words. If the user chooses the graph, LEXNET presents a network of "is-a" relations or part-whole relations, depending on the domain. For example, terms for vehicles are displayed in an "is-a" tree, shown in Figure 12, similar to the tree for weapons seen in Figure 4. Terms for Army units, on the other hand (battalion, squad, etc.), would be displayed in a part-whole tree.

Learners can also view sets of synonyms and antonyms for a given word, as shown for synonyms of "ennemi" (the French word for "enemy") in Figure 13. The learner can flip back and forth between synonyms and antonyms for a given word by touching a button. Iterative viewing of these small lexical sets is intended to strengthen the connections between a word and its synonyms and antonyms. These connections are important not only because psycholinguistic evidence shows them to be key to mental representations of words (Miller et al., 1988), but also because synonym and antonym exchanges are a typical way to structure discourse, as illustrated in the sentence samples shown earlier.

Another capability of LEXNET lets learners form their own networks to practice what they've seen and to build new links. The learner chooses to deal with a relationship, like synony, then gets an assortment of words on the screen, some of which form synonyms, as illustrated in Figure 14. The learner employs HyperCard facilities to move the words around, place the synonyms together, and draw links between them.

Téhéran et Bagdad s'accusent de violer le cessez-le-feu

Des **espions** iraniens ont affirmé que les troupes irakiennes avaient **détenu** 700 soldats iraniens depuis le cessez-le-feu le 20 août et les avaient **internés**. Ces **captifs**, après leur libération, ont **renseigné** l'Iran sur des terroristes qui continuaient de faire les actes de violence contre le peuple iranien.

↕
↕

Figure 10. A paragraph introducing French military vocabulary, from LEXNET-in-Situ.

Téhéran et Bagdad s'accusent de violer le cessez-le-feu

Des **espions** iraniens ont affirmé que les troupes irakiennes avaient **détenu** 700 soldats iraniens depuis le cessez-le-feu le 20 août et les avaient internés. Ces **captifs**, après leur libération, ont renseigné l'Iran sur **actes de violence** qui continuaient de faire les iraniens.

écoutez

réseau

grammaire

traduction

phrase

exemplaire



Figure 11. A pop-up menu of information choices about a selected word from the LEXNET-in-Situ paragraph.

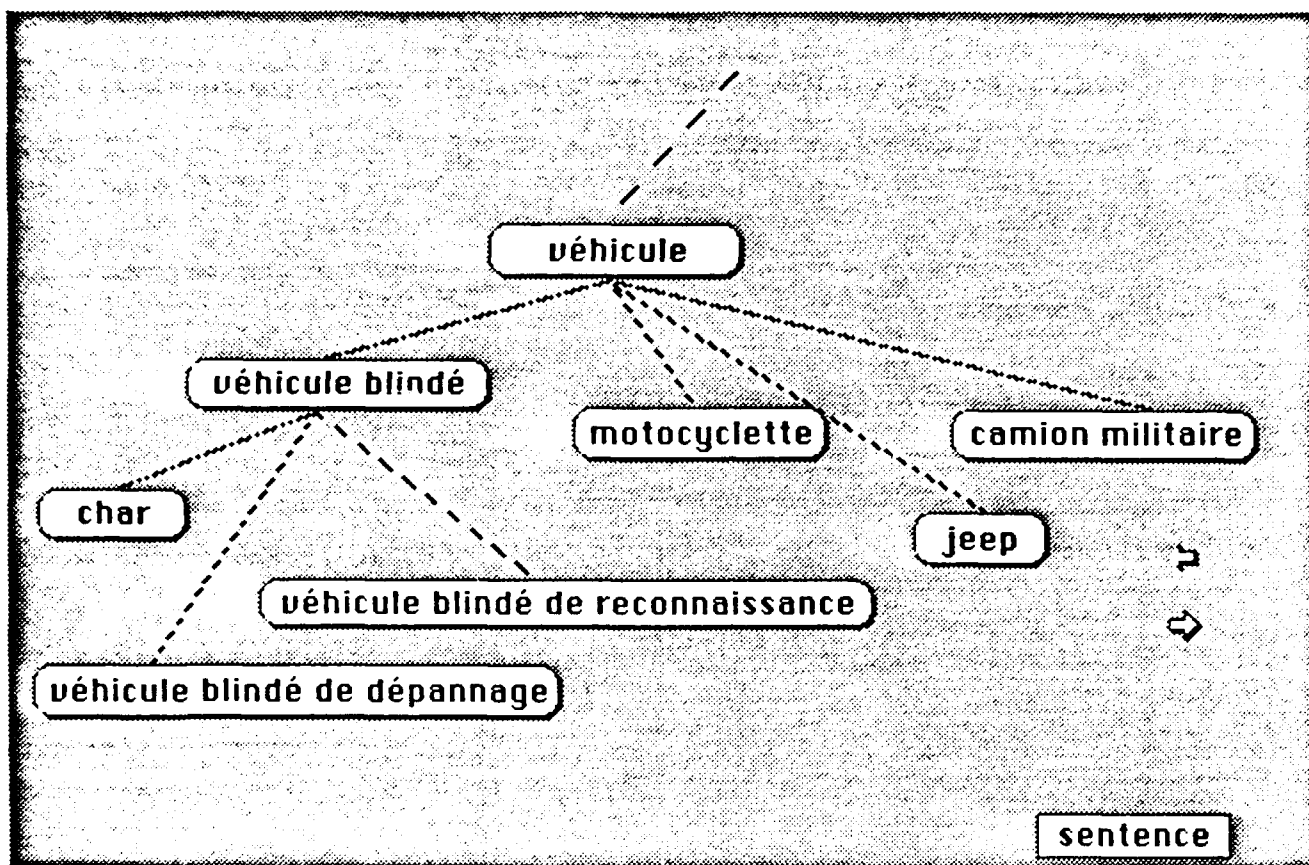


Figure 12. A graphical display showing the relative meanings of French words for military vehicles, from LEXNET-in-Situ.

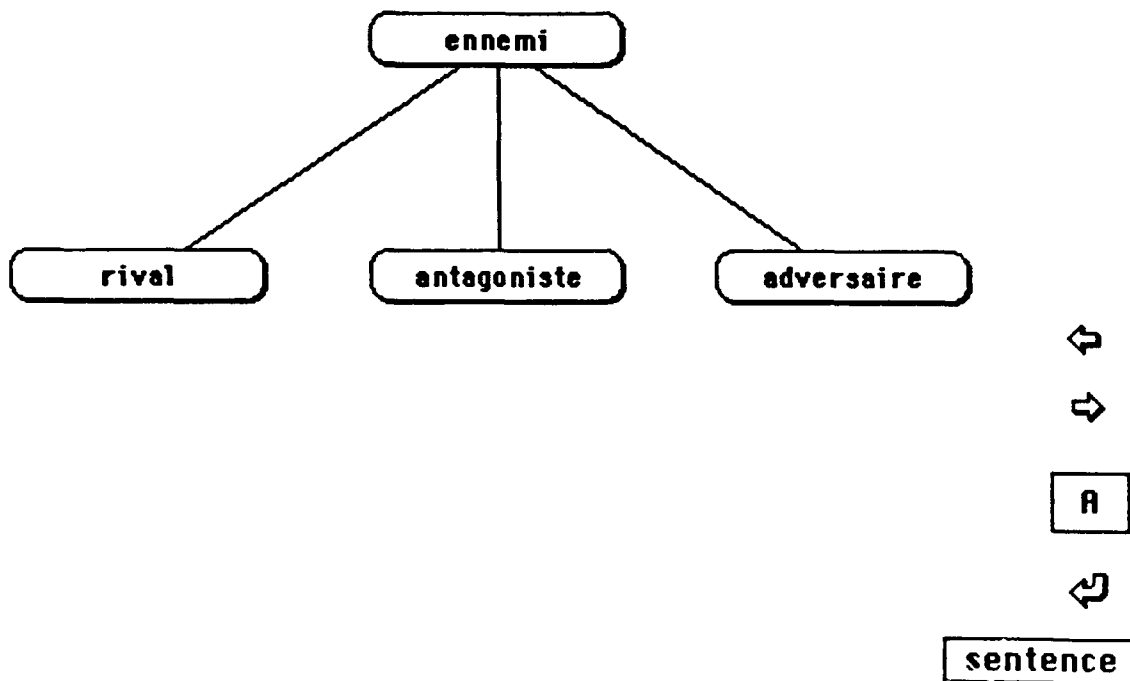


Figure 13. A graphical arrangement of synonyms for "ennemi" (touching the "A" button switches the three synonyms to antonyms of "ennemi").

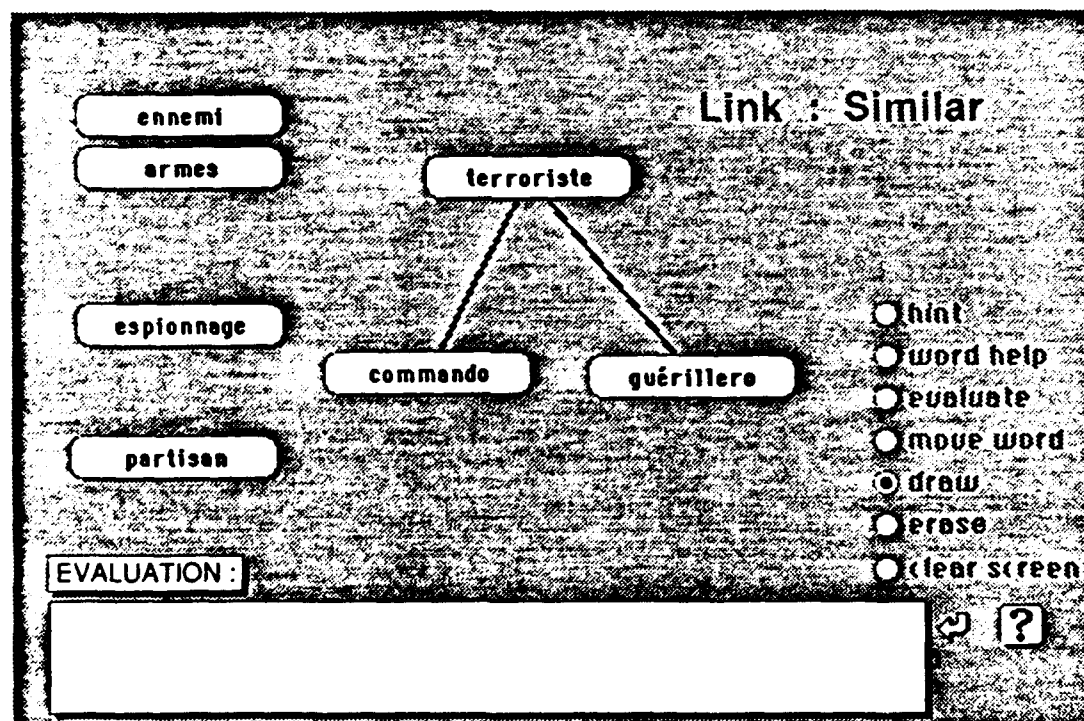
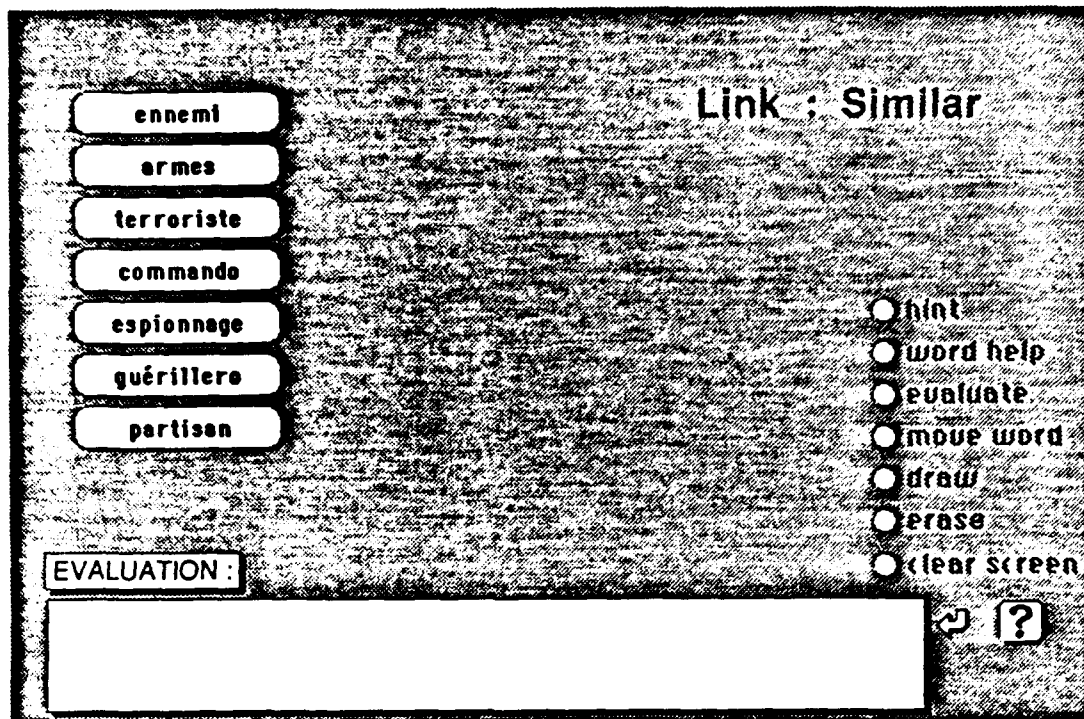


Figure 14. A synonym grouping exercise in which learners use hypertext facilities to move words around and draw links between them.

Having started with a discourse context, learners can return to it. In one of the lessons, they can use words from the lexical networks to complete sentences. Learners insert the correct forms of a selected noun and verb into a provided sentence frame to see how the words look together and to practice their morphological variations. For example, given a choice of four verbs and four nouns, the learner might choose "emprisonner" (imprison") and "terroriste" ("terrorist"). A sentence frame then appears:

"Ils _____ (passe compose) un _____."
(They _____ (past tense) a _____.)"

The task is to insert the appropriate forms of "emprisonner" and "terroriste" into the blanks.

Another discourse lesson both tests and exercises the use of words in context. This lesson is based on the cloze technique (Deyes, 1984), which assesses linguistic knowledge by the ability to predict missing words in a sentence or text (e.g., fluent speakers of American English can readily supply the missing word in "April showers bring May ____"). In this lesson paragraphs are presented with occasional blanks, as in Figure 15, and the learner fills the blanks with words from a list on the screen. The program delivers feedback on the correctness or appropriateness of the cloze response. The response scoring procedure accepts synonyms, so that the user can try out different ways of filling a blank. From the cloze lesson - as well as from any point in the network displays and the sentence completion tasks - the learner can access pronunciations and translations by clicking once and twice respectively on the word in question.

Thus, LEXNET extends the preceding hypertext programs not only by contextualizing word networks but also by combining comprehension with production lessons. The aim of this mix of exercises is to coordinate lexical knowledge, in the form of abstract semantic networks, with the use of this knowledge in concrete tasks of reading and writing.

Conclusions and Future Prospects

All three of the programs we have reviewed incorporate the network principle of presenting word meaning. The purpose of the network displays is to establish paths in the learner's memory between words that are highly associated in the target language - synonyms, antonyms, meronyms, and metonyms - and to strengthen these paths for easy passage. Being able to traverse these paths rapidly and automatically should help learners better understand and use words in natural encounters with the target language.

LEXNET-in-Situ additionally incorporates the discourse principle of presenting word meaning. The purpose of its text and sentence exercises is to demonstrate how lexical structure maps into discourse and to help learners practice the integration of language and lexicon. drawbacks are best defined in terms of two distinct instructional functions of networks, as seen in the programs above:

Après la mort de trois terroristes de l'IRA

Dans un communiqué, l'IRA a admis que l'explosion d'une bombe à Londonderry s'agissait d'une "erreur". Deux personnes ont été _____ et une troisième blessée par l'explosion des _____ dans un appartement. Les _____ de l'IRA, partie d'une opération de commando, avaient _____ dans l'appartement par la fenêtre. Cette opération a déclenché une nouvelle vague de troubles. Le 31 août, deux _____ britanniques ont été _____ dans plusieurs quartiers catholiques de Belfast-Ouest. Trois membres de l'IRA avaient été _____ par des _____ britanniques. Les forces de sécurité ont fait usage de leurs _____ pour disperser de petits groupes de manifestants.

Mots

arme de main
terroriste
char
explosif au plastic

tuer
pénétrer
soldat
interroger

show/hide field(s)



Figure 15. A cloze (fill-in-the-blank) exercise from LEXNET-in-Situ.

The display function involves showing the meaning of a new word iconically, by its position in semantic space or its labeled relation to known words (for example, words at the endpoints of a continuum).

The integration function involves teaching and strengthening the links between words whose meanings are already known.

Both functions are essential in language learning: Learners must first grasp the meaning of a new word, then integrate it with related words to approximate the lexical structure of a native speaker.

Concerning the display function, a drawback of networks such as the word trees in Figures 4 and 12 is their complexity. They may be too cumbersome to help students decipher meaning, which may be better depicted through pictures of the referent or through clear example sentences. Rather than teaching the meaning of new words, networks may be better used to show connections between known words.

Concerning the integration function, however, networks could have other drawbacks. The structure of a network may vary with viewpoint and may assume or require a specific context to make sense. Even strictly logical relations like "is-a" could shift depending on the topic being considered or the goal of organizing the "is-a" domain. For example, an is-a hierarchy of animal names might in the context of zoological classification group "horse" and "zebra" under equine animals and "cow" under bovine. But in the context of geography or function, the hierarchy might separate "zebra" under wild animals and subsume "horse" and "cow" under domestic animals. Apparently, even a well-defined relation like "is-a" is not adequately represented by a static set of connections such as proposed in WordNet. If the pure lexical hierarchy outside of context is mythical, then it may be necessary at least to supplement basic network structures with authentic samples of discourse, in order to present the connections learners need. That is, it may be easier to present discourse contexts that can potentially change hierarchical alignments than it is to present multiple hierarchical alignments in an attempt to predict structure-changing contexts. (Note that at the other extreme of static networks is the technique of semantic mapping, described by Oxford [in preparation] which allows students to invent their own organizing principles and to select and group words carte blanche.)

Just as lexical relations help to structure discourse, so they originate from discourse. Native speakers do not generally see and practice semantic abstractions like networks. Rather, they participate in discourse and extract frequently repeated relationships from context. Massive exposure to discourse is clearly the more natural way to acquire connections (Krashen, 1982). The question for a user evaluation is whether lexical networks can distill essential experience and condense it into a manageable span of time for second language learning.

Another potential drawback of networks is their lack of interactivity. Is passive viewing of links optimal or even sufficient

to teach lexical relations? The effectiveness of network displays may vary between students. Some students may like and profit from the exploratory learning assumed by these displays. The question for a user evaluation is whether students who like and profit from this method have common characteristics that can guide future application of network browsers. For students who need more direction than is assumed by a browser, networks could be made more responsive - with opaque nodes, prompts for response, and presentation of feedback.

Finally, semantic networks may have limited suitability for translation into foreign languages. The assumption behind translated networks is that languages share a conceptual interlingua - a common set of schemas - for given domains, and that semantic networks capture the structure of this interlingua. Thus, domains like weapons or animals would have the same structure from one language to the next. This assumption appears valid in strictly technical domains, where the logic is well-defined, the referential ground is common, and the referents of the words are fixed. The logic of such domains should vary little across languages. In non-technical domains - what may be called "folk" or common discourse (Powell, 1989) - the surrounding culture and context may mold semantic structure from one language to the next. Variations in semantic structure might be ascertained through distributional analyses of language samples or through comparative studies of word sorting in native speakers (Note 5). If semantic structure varies between a first and second language, then second language learners must acquire new concepts and connections, and system designers must construct network configurations anew for the second language.

NOTES

1. Besides knowledge of technical terminology, other job-specific language skills include ability to use syntactic patterns and discourse conventions that are peculiar to an occupation. For example, interrogation requires mastery of elaborate question-asking structures as well as flexibility in different discourse registers (levels of formality and intimacy) in a second language. To address language skills beyond the word, ARI is conducting research under contract that uses artificial intelligence technologies to develop dialog-based second language instruction (see Swartz and Psotka, 1989).
2. Translation tasks of this sort - although secondary to the speaking tasks required of interrogators - are part of the job that 97Es do in the field. Tests of translation are, in fact, intended to approximate assessments of spoken skill, which are too expensive to administer in each target language. Note that the determining tests for 97Es at Ft. Huachuca are simulated oral interrogations conducted in English.
3. The notion of lexical representation is sometimes used interchangeably with that of conceptual representation. One form maps to the other, since words symbolize concepts. Yet, following Miller and Johnson-Laird (1975), we maintain the distinction here. As Miller and Charles (1988) point out, phenomena like direct antonymy (e.g., the speed of recognizing the contrast "wet-dry" as opposed to "wet-arid") are purely lexical. They depend on the frequency of occurrence and co-occurrence of particular word tokens in the language. Priming is also a lexical phenomenon: it occurs between words and not concepts (e.g., "wet" primes "dry" but not "arid"). Furthermore, Miller (1969) deems functional relations between words - like that between "jack" and "wheel" - to be non-lexical. We consider lexical phenomena, as reflected in word recognition and priming studies, independently important in the acquisition of language fluency.
4. Alternatively, it might be hypothesized that presenting words together from the same semantic domain would increase interference effects between newly learned items. Second language acquisition is clearly open to interference effects - between native and target language, for example, or between target language words that sound similar. However, interference is probably greater when related words are presented separately in time and space, because it is harder for learners to compare and encode their distinctive features. We therefore consider the strengthening hypothesis of grouped presentation more plausible than the interference hypothesis.
5. To adequately represent the semantics of a language would, of course, require more than statistical exercises. Anthropological linguists (e.g., Agar, 1989) call for interviews with native speakers, as well as observations of word usage that note the complexities of context, in order to describe the web of cultural associations that even simple words carry with them.

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